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Specification and Drawings as originally filed, with Application for Patent Serial No: **2,389,086,** on June 5, 2002, by **IMPERIAL SHEET METAL LTD.,** assignee of Bertrand Poirier and Bertrand Michaud, for "Flow Balancing System".

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FLOW BALANCING SYSTEM

FIELD OF THE INVENTION

The present invention pertains to the field of fluid flow control.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a flow balancing system. In accordance with an aspect of the present invention, there is provided an apparatus for controlling a system of the type which includes a fluid conduit system, motors each drivingly engaged with different fluid movement systems, the apparatus comprising means for providing a speed signal representative of the speed of each motor and means for providing a control signal in response to the speed of each motor and finally means for controlling the speed of each motor in response to the control signal wherein each motor speed is controlled for balancing the rate of fluid movement at an input point and an exit point of the system.

In accordance with another aspect of the invention, there is provided a system for balancing the rate of fluid movement, wherein the system comprises motors, each in driving relationship with a respective fluid movement system and means for providing speed signals representative of the speed of each motors and a microprocessor, responsive to the speed signal, for generating control signals which is a function of the speed signals and finally a variable speed motor controls for controlling the motor speeds in response to control signals

In accordance with another aspect of the invention, there is provided a method for controlling a system of the type which includes a fluid conduit system, motors each drivingly engaged with different fluid movement systems, the method comprising the steps of sensing the speed signal representative of the speed of each motors in the system and generating, by the use of a microprocessor, control signals in response the speed of the each motor and transmitting a

command to each motor in response to the control signals, the command adjusting the motor speeds thereby balancing the rate of fluid movement at an input point and an exit point of the system.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 is a schematic of one embodiment of the present invention;
Figure 2 is a logic diagram of one embodiment of the present invention;
Figure 3 is a graph of the application of the system of one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Definitions

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs.
The present invention provides a system that enables the balancing of the rate of fluid movement within a fluid conduit system. With reference to Figure 1, the system **10** comprises a fluid conduit system **20** within which the fluid moves and at least two motors **40** which are drivingly engaged with separate fluid movement systems **30**. The system further comprises at least one variable speed motor controller **50** which controls the speed of the each of the motors and a microprocessor **60** which provides a means for the determination of the adjustments required in order to balance the rate of fluid movement within the fluid conduit system **20**. Optionally, a variable speed motor controller is provided for each motor within the system.

The fluid conduit system can be any type of system which provides a means for the movement of a fluid, for example, a duct system can provide for the movement of air and a pipe system can provide for the movement of a liquid. A worker skilled in the art would understand what type of fluid conduit system would be appropriate for allowing the movement of a particular fluid.

A fluid movement system (FMS) can be any type of system which moves of a fluid, wherein a fluid movement system must be compatible with the fluid to be moved. For example, a blower would be appropriate for the movement of air and a pump would be appropriate for the

movement of a liquid. A worker skilled in the art would understand what type of fluid movement system would be appropriate for the movement of a particular fluid. In one embodiment, the fluid is air and a blower may be an appropriate fluid movement system, wherein a blower is a device such as a fan, for causing air to flow through the fluid conduit system and is typically installed therein. A blower may comprise a forward curved centrifugal fan, or may be any other type of blade, fan or other device for moving air.

The motors are devices which provide the necessary mechanical power for driving the fluid movement system. For example, a motor may be electrically powered or may be a combustion type motor or any other type of motor as would be known to a worker skilled in the art. The type of motor can be determined based on the application for which the system is being used. For example, electrical motors may be used in conjunction with an air system as is typically seen in heating, ventilation and air conditioning (HVAC) systems. A motor can be drivingly engaged with a fluid movement system though the use of a pulley system or a gearing system or any other type of mechanism which is capable of transmitting the power from the motor to the fluid movement system. In one embodiment of the invention a motor and a fluid movement system are integrated into one device such that the motor may be inserted within a fluid movement system.

A variable speed motor controller (VSMC) is a means for controlling the speed of a motor in response to a control signal generated by the microprocessor and a means for providing the motor speed signal representative of the speed of a particular motor. Alternately, the motor speed signal may be provided by a separate device such as a commutation circuit commonly used in combination with electronically commutated motors. A variable speed motor controller is responsive to a control signal representative of a desired speed for the motor and is electrically connected to the microprocessor for receiving the control signal. A variable speed motor controller subsequently transmits a command to a motor, wherein the command represent the control signal previously received from the microprocessor. This command adjusts the speed of the motor to the speed as determined by the microprocessor. As would be known to a worker skilled in the art, the control signal may take a variety of forms for example, a pulse width modulation signal, a pulse amplitude modulation signal, a pulse position modulation signal or a

pulse code modulation signal. The design of a variable speed motor controller which is capable of providing the above functions would be known to a worker skilled in the relevant art.

In one embodiment of the invention, the variable speed motor controller is electrically connected to the motor which may also be electrically driven. In this embodiment, a command transmitted from the variable speed motor controller, for controlling the motor may take an electrical form, for example a voltage, and therefore adjust the motor speed based on the transmitted command. A worker skilled in the art would understand how to calibrate a variable speed motor controller with a motor, enabling a transmitted command to produce the desired affect on the motor speed, thereby adjusting the flow of the fluid within the fluid conduit system.

The microprocessor is a means for providing a control signal in response to the fluid flow rate determined for each fluid movement system based on the speed of the respective motor. The microprocessor additionally performs actions based on an algorithm in order to generate the control signal(s) which it provides to the variable speed motor controller(s). A control signal is determined based on the balancing of the fluid flow rate within the fluid conduit system, wherein this rate may be determined based on the monitored speed of the motors powering the fluid movement systems.

In one embodiment of the invention, fluid flow meters are installed within the fluid conduit system in order to determine the actual fluid flow rate at one or more locations. Based on the actual flow rates of the fluid within the fluid conduit system, the microprocessor can determine the adjustments to the speed of the motors which is required in order to balance the fluid flow rate within the system. Optionally, the fluid flow rate may be determined in a calculated fashion, based on the speed of the motors, for example. In this case, fluid flow meters may be placed within the fluid conduit system temporarily in order to provide for the calibration of the parameters required for performing these calculations.

In one embodiment, the system of the present invention is used in a heating, ventilation and air conditioning (HVAC) system. In this type of system the motors are typically electrically driven, the fluid movement systems are a form of blower or fan and the fluid conduit system is a

collection of interconnected ductwork. Having regard to this application and a specific embodiment of the present invention, there are two blowers supplied, wherein one is employed at an intake point for the insertion of fresh air into the HVAC system and the second blower is employed at an exhaust point wherein the stale air is removed from the system. As would be known to a worker skilled in the art, efficiency of the system may be improved if the air flow rate into and out of the system is equilibrated. This may be enabled through the adjustment of the motors operating the intake and exhaust blowers, for example. In addition, by balancing the intake and exhaust air flow rate, the noise associated with the operation of the blowers may be minimized. This may be a result of the maintenance of an equal pressure within the duct system as opposed to an increase or decrease in the pressure within the system, which may occur if the air flow rate into the system is different from the air flow rate out of the system.

In one embodiment of the invention, initially the fluid flow rate within the fluid conduit system is determined at a number of positions, wherein each position corresponds to the location of a fluid movement system. This fluid flow rate is established at a preselected power level for the system, for example, when maximum power is applied to each fluid movement system. The fluid flow rate at each position can be established by direct measurement of the fluid flow rate or by calculating the fluid flow rate based on the speed of the motor driving the fluid movement system in the vicinity of the selected position. A worker skilled in the art would understand that various parameters regarding the movement of a fluid are dependent on the particular fluid movement system being used. For example, a particular blower model which is installed in a HVAC system will displace a predetermined volume of air at a particular motor speed. Upon the determination of the fluid flow rate at each location, the subsequent step is to equilibrate the fluid flow rate at each position. This procedure will establish corresponding motor speeds for each of the fluid movement systems, thereby providing a balanced fluid flow rate within the fluid conduit system. The microprocessor establishes a difference between the motor speeds resulting in the balanced fluid flow, using these determined motor speeds. This difference is applied to each other power level setting for each of the motors. In this manner, irrespective of the power level at which the system is operating, the fluid flow rate will be essentially balanced based on the single balancing procedure performed. Therefore, if the balancing of the fluid flow rate is performed at the High

power setting, for example, the microprocessor will automatically apply the same balancing parameters to the Medium, and Low power levels, for example.

To gain a better understanding of the invention described herein, the following examples are set forth. It should be understood that these examples are for illustrative purposes only. Therefore, they should not limit the scope of this invention in any way.

EXAMPLE

Use with an HVAC System

Figure 2 is a logic diagram of the algorithm, according to one embodiment, used to automatically modify the low power parameter based on the high power balancing, when the HVAC system has two motors and two corresponding blowers. Beginning at block **200** labeled "Controller System Balanced", the first step consist of determining if the flow rate is being adjusted or modified. In one embodiment, the flow rate is adjusted by either increasing or decreasing the speed of the motors in the system. If the motor speeds are increased or decreased, the microprocessor will automatically detect a difference in the motors default speed settings and detect an adjustment of the flow rate **210**. At this point, as shown in block **220**, the microprocessor will read the high speed settings for each motor. In step **230**, the microprocessor will then determine which motor has the highest speed by implementing the following algorithm: High Speed Fan 1 > High Speed Fan 2 where High Speed Fan 1 is the speed for one motor and High Speed Fan 2 is the speed of another motor. If High Speed Fan 1 is greater than High Speed Fan 2 then the microprocessor will determine the difference between both high speeds **240**. Alternatively, the microprocessor will determine the difference between both high speeds through block **250**. Once the difference between both high speeds are determined either through **240** or **250**, the low setting for the motor with the highest speed will be read **260** or **270**. Once the low speed is read, **260** or **270**, the difference in speed established at **240** or **250** will be added to the low setting **280** or **290** of the motor with the highest speed level determined under block **240** or **250**. The new low value will be saved **300** or **310** and stored **320** in the microprocessor. A worker skilled in the art would understand that the updating of any values may occur continuously, intermittently or simply prior to end of the balancing of the flow rates.

In one embodiment, to determine the speed of the motors or the Speed Fan as described in the example above, the measurement of the voltage applied to each respective motor may be used. A worker skilled in the art would understand the conversion of the voltage applied to a motor in order to determine the speed of the motor.

Figure 3 is an another example of one embodiment of the present invention applied to an HVAC system which has a motor installed at the intake blower for inserting fresh air and another motor installed at the exhaust blower removing stale air. The bottom graph shows the air flow rate and the top graph shows the power applied to the motors described above for the HVAC system. Initially, no power is applied to the motors in the HVAC system **400**. Through start-up, power is then applied to the motors in the HVAC system which in turn creates an air flow in the system. The air flow rate slowly increases as the power is applied **410**. Through the stages **400** and **410**, the flow balancing system of the present invention is not applied to the HVAC system. At stage **420**, the flow balancing system is applied to the HVAC system wherein the power to the motors of the HVAC system are increased to maximum power, wherein the air flow increases gradually as the motors increase to maximum power. At stage **430**, the air flow is rate balanced by reducing the power to one or both of the motors of the HVAC system. The power to the motors in the HVAC system are modified until both air flows from the intake and the exhaust are at approximately the same rate, for example, 150 cubic feet per minute as shown in the bottom graph of Figure 3. More specifically, under this example, the power to the exhaust blower is reduced **440** since the air flow from the stale exhaust blower is greater than the intake blower. The measurement of the air flow may be conducted through the use of sensors automatically connected to a microprocessor. Under such an embodiment, the microprocessor can then also automatically adjust the speed of the motors in the HVAC system in order to balance the air flow rate in the HVAC system. Alternatively, the air flow rate can be measured independently of the microprocessor through the use of measurement equipment temporally installed at the intake and exhaust parts of the HVAC

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention,

and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. An apparatus for controlling a system of the type which includes a fluid conduit system, motors each drivingly engaged with different fluid movement systems, the apparatus comprising:

means for providing a speed signal representative of the speed of each motor;

means for providing a control signal in response to the speed of each motor;

means for controlling the speed of each motor in response to the control signal wherein each motor speed is controlled for balancing the rate of fluid movement at an input point and an exit point of the system.

2. A system for balancing the rate of fluid movement, wherein the system comprises:

motors, each in driving relationship with a respective fluid movement system;

means for providing speed signals representative of the speed of each motors;

a microprocessor, responsive to the speed signal, for generating control signals which is a function of the speed signals; and

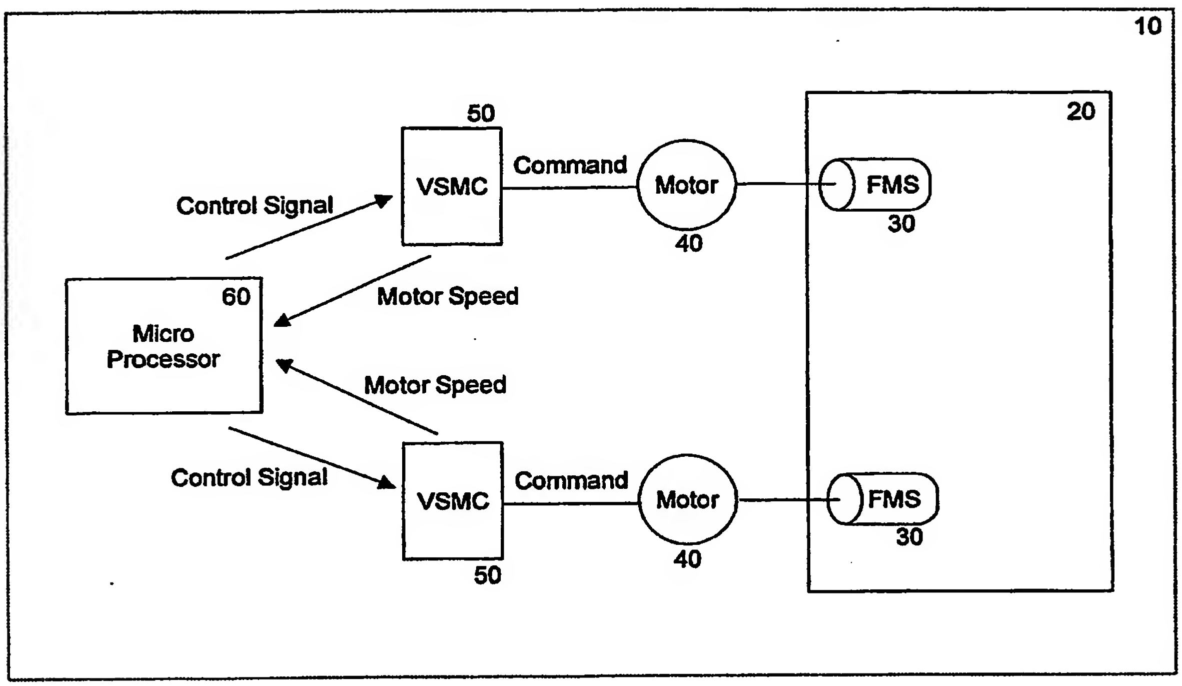
variable speed motor controls for controlling the motor speeds in response to control signals

3. A method for controlling a system of the type which includes a fluid conduit system, motors each drivingly engaged with different fluid movement systems, the method comprising the steps of:

sensing the speed signal representative of the speed of each motors in the system;

generating, by the use of a microprocessor, control signals in response the speed of the each motor;

transmitting a command to each motor in response to the control signals, the command adjusting the motor speeds thereby balancing the rate of fluid movement at an input point and an exit point of the system.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20
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Motor
FMS
30
40
Control Signal
60
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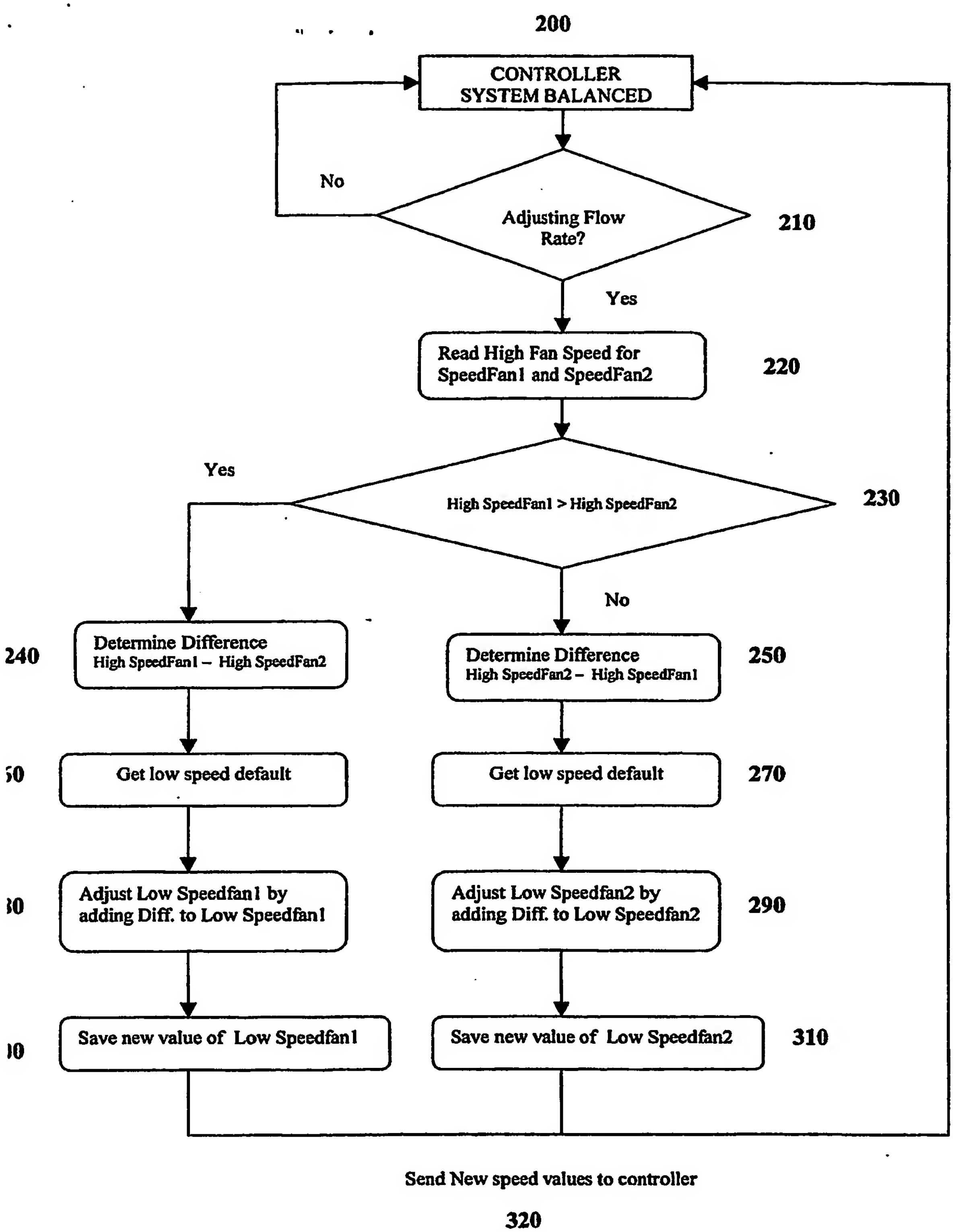
Processor
Motor Speed
Motor Speed
Control Signal
VSMC
Command
Motor
FMS
30
40
50

FIGURE 1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SYSTEM BALANCED
No
Adjusting Flow
Rate?
210
Yes
Read High Fan Speed for
SpeedFan1 and SpeedFan2
220
Yes
High SpeedFan1 > High SpeedFan2
230
No
240
Determine Difference
High SpeedFan1 – High SpeedFan2
Determine Difference
High SpeedFan2 – High SpeedFan1
250
Get low speed default
Get low speed default
270
Adjust Low Speedfan1 by
adding Diff. to Low Speedfan1
Adjust Low Speedfan2 by
adding Diff. to Low Speedfan2
290
Save new value of Low Speedfan1
Save new value of Low Speedfan2
310
Send New speed values to controller
320

FIGURE 2

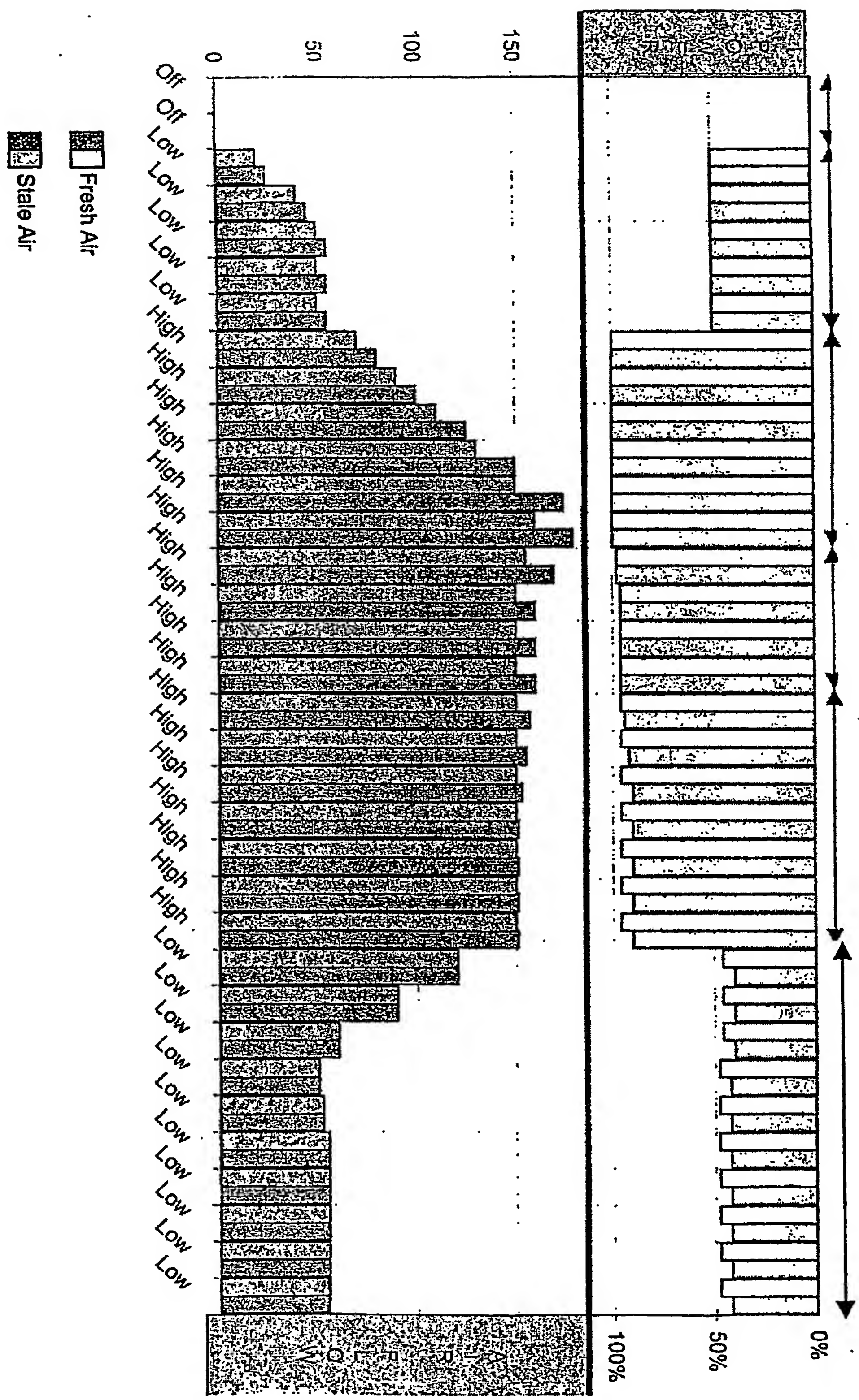

FIGURE 3

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